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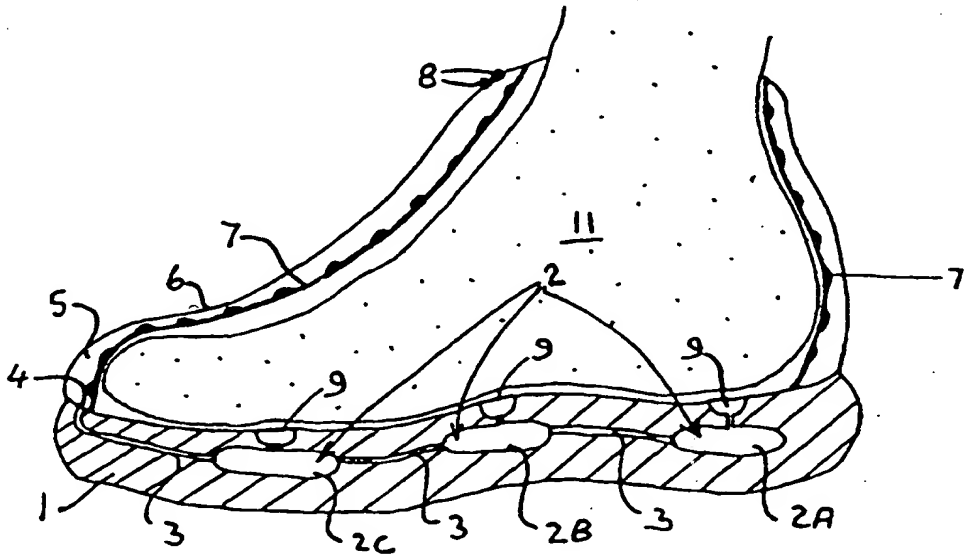

(57) Abstract

An article of footwear having a ventilated sole (1), the sole being formed of a substantially impermeable resilient material and having internally an air reservoir arrangement (2/3) connected to the interior of the footwear via perforations (9), each of which has along its length a relatively wide region (9A) open to the interior of the footwear and a relatively narrow region (9B) connecting the relatively wide region (9A) to the air reservoir arrangement (2/3). The sole has a ventilation arrangement (4/5/8) serving for venting the air reservoir arrangement (2/3) externally of the footwear. The sequential compression, during the wearer's step, of reservoir chambers (2A, 2B and 2C), and the interconnecting ducts (3), in combination with the synchronous sequential occlusion of the perforations (9) by the wearer's foot, restricts or prevents back-flow of moisture laden air within the sole.

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FOOTWEAR

This invention relates to footwear and is, in particular, concerned with an article of footwear having a ventilated sole.

There are advantages in constructing footwear from impermeable materials but problems arise in wearing the footwear as such materials interfere in the natural biological functions of the wearer's skin, in particular perfusion of the skin with oxygen and removal of water vapour.

According to the present invention there is provided an article of footwear in which the sole is formed of a substantially impermeable resilient material, the sole having internally an air reservoir arrangement connected to the interior of the footwear via perforations, at least one (preferably each) said perforation having along its length a relatively wide region open to the interior of the footwear and a relatively narrow region connecting the relatively wide region to the air reservoir arrangement, the sole further having a ventilation arrangement serving for venting the air reservoir arrangement externally of the footwear.

As used herein the expressions "relatively wide" and "relatively narrow" mean that the respective regions are wide and narrow relative to each other. For the avoidance of doubt it is also to be understood that the term "sole" in the present context includes the heel portion of the sole of an article of footwear.

The arrangement for venting the air reservoir arrangement externally of the footwear can include ventilation apertures opening to the outside of the footwear adjacent the sole, for example in the toe region of the footwear, or first ventilation apertures (again suitably in the toe region of the footwear) connecting the air reservoir

arrangement to a zone between the upper outer of the footwear and a lining therefor, and second ventilation apertures remote from the first ventilation apertures and opening from said zone to the outside of the footwear, suitably at substantially the topmost part of the footwear.

Furthermore, it is preferred that each perforation itself is so formed as to restrict any tendency for air in the air reservoir arrangement to flow-back into the interior of the footwear through the perforation. Such a restriction of back-flow of air is most suitably provided for by giving the inner surface of the relatively wide region of the perforation a substantially domed or conical configuration closing towards the relatively narrow region at the apex of the dome or cone, creating a structure whereby a back pressure from the air reservoir arrangement may tend to collapse the dome or cone, closing the relatively narrow region at the apex, whereas a forward pressure from the interior of the footwear tends to open the relatively narrow region of the perforation.

Each perforation in the sole part of the footwear is preferably generally circular when viewed along its length, and suitably has a minimum internal diameter D_{min} from about 0.01 mm to about 5 mm (e.g. about 1 mm) and a maximum internal diameter D_{max} approximately 1.5 to 20 (e.g. about 1.5 to about 5) times greater than D_{min}. The centres of adjacent perforations may suitably be from about 10 mm to about 100 mm, typically approximately 20 mm, apart. The relatively narrow region of the perforation is straight-sided and is preferably no more than about 3 mm in length (more suitably about 0.5 to 2 mm) and each reservoir chamber preferably begins no more than about 5 mm (e.g. about 1 mm to about 4 mm) below the top surface of the sole. The perforations suitably taper in a domed configuration from the relatively wide regions to the relatively narrow regions, so that, for example,

each perforation has up to approximately 50% of its length tapering from D_{max} to D_{min}, and approximately 50% of its length is at D_{min}.

In some instances it may prove advantageous to construct the sole of the footwear such that the perforation wall in the relatively narrow region is capable of resiliently expanding and contracting in use between a relatively closed condition, in which the perforation is sufficiently closed off to permit air to accumulate in the relatively wide region of the perforation under increased pressure, and a relatively open condition, in which the air accumulated in the relatively wide region can pass through the relatively narrow region into the air reservoir arrangement; it is believed that such an arrangement can lead to enhanced removal of moisture from the interior of the footwear, without significantly compromising the comfort and insulative properties of the footwear.

In the case of a venting arrangement including first ventilation apertures opening the air reservoir arrangement to a zone between the upper outer of the footwear and a lining therefor, and second ventilation apertures opening therefrom to the outside of the footwear, it is preferred that the lining be composed of a fabric such as is the subject of GB Patent No. 2,242,860, that is a fabric comprising a sheet formed of a substantially impermeable elastomeric (e.g. closed-cell neoprene) material having perforations provided therethrough, each perforation of the sheet (or at least of a portion thereof) having at least one relatively wide region and at least one relatively narrow region along its length to define an internal chamber open to a first side of the sheet (this being the side of the lining directed towards the interior of the footwear) and sufficiently closed to the other side of the sheet (the side of the lining directed towards the zone between the lining and the upper outer of the footwear) to permit air

passing from the first to the other side of the sheet to accumulate in the chamber under increased pressure prior to passing to the other side of the sheet (that is into the zone between the lining and the upper outer). Such a fabric is commercially available under the brand name STOMATEX (TM) (St. Albans Rubber Limited, Stanley, County Durham, England). It will be appreciated that when such a lining is employed, air passing therethrough will thereafter exit from the zone between the lining and the upper outer, together with air from the air reservoir arrangement in the sole of the footwear, via the second ventilation apertures. Such an arrangement is particularly preferred in footwear adapted for cold weather use, since heat exchange will occur as the evacuated warm moist air passes up through the uppers of the footwear, so warming the wearer's foot.

The air reservoir arrangement preferably comprises a series of interconnected chambers within the sole of the article of footwear, most preferably in the heel, intermediate and toe regions of the article of footwear. Such chambers are compressed in sequence during the rolling motion of walking; the heel chamber(s) first as the walker's weight is initially placed on the heel of the foot, then the intermediate chamber(s) as the walker's weight is placed on the instep and ball of the foot, and finally the toe chamber(s) as the walker's weight is placed on the big toe. This sequential compression forces air in the air reservoir arrangement forwards through the sole, towards the ventilation apertures of the footwear. The chambers are suitably interconnected by air-flow passages of a dimension narrow relative to the chambers but wider than the narrow regions of the perforations connecting the arrangement to the interior of the article of footwear. The perforations suitably connect between the top of each chamber and the upper surface of the sole in the interior of the article of footwear.

The sequential compression of the reservoir chambers and air-flow passages, in combination with the synchronous sequential occlusion of the perforations by the wearer's foot and the particular configuration of the perforations, restricts or prevents back-flow of moisture laden air within the sole.

The sole part of the article of footwear is suitably constructed (e.g. by moulding and/or pressing) from conventional resilient materials used for forming footwear soles. The uppers of the article of footwear (or, where appropriate, the outer portion thereof) are suitably constructed from materials conventionally used for footwear uppers. Thus, the article of footwear suitably has similar feel and comfort properties to conventional footwear.

In use the wearer's foot can "breathe", as will be explained in more detail below, via the perforations and air reservoir arrangement in the sole, and via the lining, and so interference with the natural biological functions of the wearer's skin is minimised.

For better understanding of the invention and to show how the same may be carried into effect, reference will now be made, by way of example and without limitation, to the accompanying drawing, in which:-

Figure 1 is a diagrammatic perspective view of the inside surface and one side of the sole of a boot,

Figure 2 is a diagrammatic perspective sectional view taken on line II-II of Figure 1,

Figure 3 is a horizontal sectional view of the sole,

Figure 4 is a diagrammatic longitudinal sectional view of the sole,

Figure 5 is a sectional side view of part of the sole and part of the upper of the boot,

Figure 6 is a sectional side view of a boot similar to the boot of Figures 1 to 5, shown worn on a foot, and

Figures 7A, 7B and 7C show the boot of Figure 6 in successive stages of a step.

Referring first to Figures 1 to 5, the sole 1 is formed of a substantially impermeable resilient material, for example natural or synthetic rubber, with, internally, an air reservoir arrangement consisting of a number (in the form illustrated five) of individual reservoir chambers 2 interconnected by ducts 3 of a ventilation arrangement which, from the reservoir chamber 2 nearest the front of the sole, continue to first ventilation apertures 4 of the ventilation arrangement, this arrangement serving for venting the air reservoirs 2 externally of the boot.

In the form illustrated, the first ventilation apertures 4 open into a zone 5 between an upper outer 6 of the boot and a lining 7 therefor. In this form the ventilation arrangement is completed by second ventilation apertures 8 in the topmost part of the upper outer 6 that are remote from the first ventilation apertures 4 and which open to the outside of the boot from the zone 5. As will be explained below, the boot illustrated is a thermally insulating one for cold weather use. In an alternative boot or shoe (not illustrated) intended for other uses, the ventilation arrangement consists of the ducts 3 and a single set of ventilation apertures adjacent the sole, for example in the toe region of the boot or shoe, that are open to the outside of the boot or shoe.

Each air reservoir chamber 2 is open to the interior of the boot via perforations 9, each having a relatively wide region 9A open to the interior of the boot and a relatively narrow region 9B open to the air reservoir 2. Each perforation 9 is preferably generally circular when viewed along its length, and suitably has a minimum internal diameter D_{min} from about 0.01 mm to about 5 mm (e.g. about 1 mm) and a maximum internal diameter D_{max} approximately 1.5 to 20 (e.g. about 1.5 to about 5) times greater than D_{min}. The centres of adjacent perforations

may suitably be from about 10 mm to about 100 mm, typically approximately 20 mm, apart. The relatively narrow region of the perforation is straight-sided and is preferably no more than about 3 mm in length (more suitably about 0.5 to 2 mm) and each reservoir chamber 2 preferably begins no more than about 5 mm (e.g. about 1 mm to about 4 mm) below the top surface of the sole 1. The perforations suitably taper in a domed configuration from the relatively wide regions 9A to the relatively narrow regions 9B, so that, for example, each perforation has up to approximately 50% of its length tapering from D_{max} to D_{min}, and approximately 50% of its length at D_{min}.

The air reservoir chambers 2, ducts 3 and perforations 9 are provided in the sole 1 by conventional moulding and/or pressing processes, as will be readily appreciated by one skilled in this art.

The lining 7, which provides thermal insulation, is composed of any of the fabrics forming the subject of GB Patent No. 2,242,860, to which reference is directed. As GB 2,242,860 contains full description of the fabric, and the nature of its thermal insulating properties, detailed description will not be given herein. Suffice to say that the fabric comprises a sheet 7A formed of substantially impermeable material having perforations 7B provided therethrough, each perforation of the sheet 7A (or at least a portion thereof) having at least one relatively wide region and at least one relatively narrow region along its length to define an internal chamber open to the first side of the sheet (this being the side of the lining 7 directed towards the interior of the boot) and sufficiently closed to the other side of the sheet (the side of the lining 7 directed towards the zone 5 between the lining 7 and the upper outer 6 of the boot) to permit air passing from the first to the other side of the sheet (from inside towards the outside of the boot) to accumulate in the chamber under increased pressure prior to passing to the other side of the sheet (that is

into the zone 5 between the lining 7 and the upper outer 6). It is preferred to use the commercially available STOMATEX (TM) closed-cell neoprene fabric, available from St. Albans Rubber Limited, Stanley, County Durham, England.

The lining 7 is free from attachments to the body of the boot except where it meets the sole 1, that is at 10 in Figure 4, and around the ankle opening.

In use, in the manner fully described in GB-2,242,860, air laden with moisture from the foot of the wearer constantly passes through the lining 7 into the zone 5. From here it is exhausted to the outside of the boot through the ventilation apertures 8.

Furthermore, air laden with moisture from the sole of the wearer's foot passes via the perforations 9, air reservoir chambers 2, ducts 3 and ventilation apertures 4 also into the zone 5 to be exhausted therefrom through the ventilation apertures 8. It is in this way that the wearer's foot is allowed to "breathe".

Referring now to Figure 6 and Figures 7A, 7B and 7C in which the boot shown has its air reservoir chambers 2 shown diagrammatically arranged as a posterior or heel air reservoir chamber 2A, an intermediate or instep air reservoir chamber 2B and a forward or toe air reservoir chamber 2C, but which in practice would be as the boot of Figures 1 to 5, it will be seen that when the foot 11 wearing the boot is clear of the ground (Figure 6), all the air reservoir chambers 2A, 2B and 2C, and all the ducts 3 are fully open. In this condition moisture laden air tends to pass through the perforations 9 into the chamber 2 by virtue of (a) a positive vapour pressure gradient from the saturated vapour in the boot to the unsaturated wide region 9A of the perforations 9, that is by diffusion, (b) thermal convection from the high temperature region of the interior of the boot to the low

temperature region of the chambers 2 and (c) saturated vapour naturally collecting in the wide regions 9A for forced convection into the chambers 2 when the sole is compressed.

As shown in Figures 7A to 7C, the passage of the moisture laden air to the ventilation apertures 4 is facilitated by the action of normal walking in which, at each step, first the heel is placed on the ground (Figure 7A) and then a progressive contact involving the rest of the foot occurs (Figures 7B and 7C), in the manner of a rolling wave. Once the toe end of the foot is in contact with the ground (Figure 7C) the heel begins to lift off until the whole foot is clear of the ground (Figure 6). Then the process repeats itself. As pressure is thus applied, air in the wide regions 9A of the perforations 9 is first forced into the chambers 2. At the same time the foot in contact with the perforations occludes the wide regions 9A to prevent back-flow into the interior of the boot. Moreover, the rolling wave of the foot causes compression of the posterior or heel air reservoir chamber 2A first (Figure 7A), thus forcing the air contained within it to move forward via the ducts 3 into the intermediate or instep air reservoir chamber 2B (Figure 7B). This process continues with the ducts and the chambers being progressively compressed as the foot progressively bears down on the sole until at the end of the cycle (Figure 7C) substantially all of the moisture laden air is pumped from the air reservoir chambers 2A, 2B and 2C and the ducts 3 into the zone 5 between the upper outer 6 and the liner 7. During this process the construction of the perforations 9 causes the relatively narrow regions 9B of the perforations to constrict against any air pressure in the chambers 2A, 2B and 2C, further to limit back-flow of moist "spent" air into the interior of the footwear.

During each step as the heel begins to lift off the ground again the posterior air reservoir chamber 2 regains its original shape and volume by elastic recoil.

As this reservoir chamber expands, more moisture laden air is drawn thereinto from the boot interior, and into the other chambers 2B and 2C as they regain their original shapes and volumes, to be expelled during the next step, and this process is continuous as normal walking continues. There is a pumping action forcing evacuation of excess water vapour from the boot.

It is to be noted that the ducts 3, as well as the chambers 2, collapse as downward pressure is applied by the foot, thereby to prevent back-flow from chamber to chamber.

The construction described is suitable for all types of cold weather boots with a substantial sole, the material selected for the sole being suitable for achieving the necessary compression and expansion of the air reservoir chambers.

Thermal insulation is not compromised and indeed a heat exchange will be experienced as the evacuated warm, vapour filled air passes up between the upper outer 6 and the lining 7.

As already stated, in footwear not intended for cold weather use, the lining 7 can be omitted and ventilation apertures to the outside can be provided to replace the apertures 4.

CLAIMS

1. An article of footwear in which the sole is formed of a substantially impermeable resilient material, the sole having internally an air reservoir arrangement connected to the interior of the footwear via perforations, at least one said perforation having along its length a relatively wide region open to the interior of the footwear and a relatively narrow region connecting the relatively wide region to the air reservoir arrangement, the sole further having a ventilation arrangement serving for venting the air reservoir arrangement externally of the footwear.

2. An article of footwear as claimed in claim 1, wherein each said perforation has a said relatively wide region and a said relatively narrow region.

3. An article of footwear as claimed in claim 1 or 2, wherein the ventilation arrangement for venting the air reservoir arrangement externally of the footwear includes ventilation apertures opening to the outside of the footwear adjacent the sole.

4. An article of footwear as claimed in claim 3, wherein the ventilation apertures open to the outside in the toe region of the footwear.

5. An article of footwear as claimed in claim 1 or 2, wherein the ventilation arrangement for venting the air reservoir arrangement externally of the footwear includes first ventilation apertures connecting the air reservoir arrangement to a zone between the upper outer of the footwear and a lining therefor, and second ventilation apertures remote from the first ventilation apertures and opening from said zone to the outside of the footwear.

6. An article of footwear as claimed in claim 5, wherein said first ventilation apertures are in the toe region of the footwear.

7. An article of footwear as claimed in claim 5 or 6, wherein said second ventilation apertures open to the outside of the footwear at substantially the topmost part of the footwear.

8. An article of footwear as claimed in any one of the preceding claims, wherein the or each perforation itself is so formed as to restrict any tendency for air in the air reservoir arrangement to flow back into the interior of the footwear through the perforations.

9. An article of footwear as claimed in claim 8, wherein for restricting back-flow of air the inner surface of the relatively wide region of the perforation is of a substantially domed or conical configuration closing towards the relatively narrow region at the apex of the dome or cone, creating a structure whereby a back pressure from the air reservoir arrangement may tend to collapse the dome or cone, closing the relatively narrow region at the apex, whereas a forward pressure from the interior of the footwear tends to open the relatively narrow region of the perforation.

10. An article of footwear as claimed in any one of the preceding claims, wherein the or each perforation is preferably circular when viewed along its length, and suitably has a minimum internal diameter D_{min} from about 0.01 mm to about 5 mm and a maximum internal diameter D_{max} approximately 1.5 to 20 times greater than D_{min}.

11. An article of footwear as claimed in claim 9, wherein said minimum internal diameter D_{min} is about 1 mm and said maximum internal diameter D_{max} is about 1.5 to about 5 times greater than D_{min}.

12. An article of footwear as claimed in claim 10 or 11, wherein the or each perforation tapers in a domed configuration from the relatively wide region to the relatively narrow region so that up to approximately 50% of its length tapers from D_{max} to D_{min}, and approximately 50% of its length is at D_{min}.

13. An article of footwear as claimed in any one of the preceding claims, wherein the perforation wall in the relatively narrow region is capable of resiliently expanding and contracting in use between a relatively closed condition, in which the perforation is sufficiently closed off to permit air to accumulate in the relatively wide region of the perforation under increased pressure, and a relatively open condition, in which the air accumulated in the relatively wide region can pass through the relatively narrow region into the air reservoir arrangement.

14. An article of footwear as claimed in any one of the preceding claims, wherein the centres of adjacent perforations are from about 10 mm to about 100 mm apart.

15. An article of footwear as claimed in claim 14, wherein said centres are approximately 20 mm apart.

16. An article of footwear as claimed in any one of the preceding claims, wherein the or each relatively narrow perforation region is straight-sided and is no more than about 3 mm in length.

17. An article of footwear as claimed in claim 16, wherein the or each relatively narrow perforation region is about 3 mm in length.

18. An article of footwear as claimed in claim 5 or any one of claims 6 to 17 as appendant directly or indirectly to claim 5, wherein the lining is a fabric comprising a sheet formed of a substantially impermeable elastomeric

material having perforations provided therethrough, each perforation of at least a portion of the sheet having at least one relatively wide region and at least one relatively narrow region along its length to define an internal chamber open to a first side of the sheet (this being the side of the lining directed towards the interior of the footwear) and sufficiently closed to the other side of the sheet (the side of the lining directed towards the zone between the lining and the upper outer of the footwear) to permit air passing from the first to the other side of the sheet to accumulate in the chamber under increased pressure prior to passing to the other side of the sheet (that is into the zone between the lining and the upper outer).

19. An article of footwear as claimed in claim 18, wherein the substantially impermeable elastic material is closed-cell neoprene.

20. An article of footwear as claimed in any one of the preceding claims, wherein the air reservoir arrangement comprises a series of interconnected chambers within the sole of the article of footwear arranged to be compressed in sequence during the rolling motion of walking.

21. An article of footwear in which the sole is formed of a substantially impermeable resilient material, the sole having internally an air reservoir arrangement connected to the interior of the footwear via perforations, wherein the air reservoir arrangement comprises a series of interconnected chambers within the sole of the article of footwear arranged to be compressed in sequence during the rolling motion of walking, the sole further having a ventilation arrangement serving for venting the air reservoir arrangement externally of the footwear.

22. An article of footwear as claimed in claim 20 or 21, wherein said interconnected chambers are in the heel,

intermediate and toe regions of the article of footwear so that during the rolling motion of walking the heel chamber(s) is/are compressed first as the walker's weight is initially placed on the heel of the foot, then th intermediate chamber(s) as the walker's weight is placed on the instep and ball of the foot, and finally the toe chamber(s) as the walker's weight is placed on the big toe.

23. An article of footwear as claimed in claim 20, wherein the chambers are interconnected by air-flow passages of a dimension narrow relative to the chambers but wider than the narrow region(s) of the perforation(s) connecting the arrangement to the interior of the article of footwear.

24. An article of footwear as claimed in any one of claims 20 to 23, wherein the perforation(s) connect between the top of the chamber(s) and the upper surface of the sole in the interior of the article of footwear.

25. An article of footwear, substantially as hereinbefore described with reference to Figures 1 to 5 or Figures 6 and 7A, 7B and 7C of the accompanying drawings.

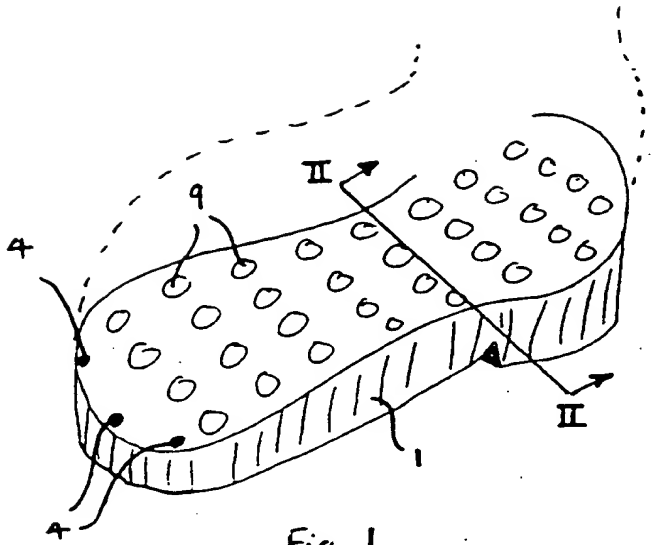


Fig. 1

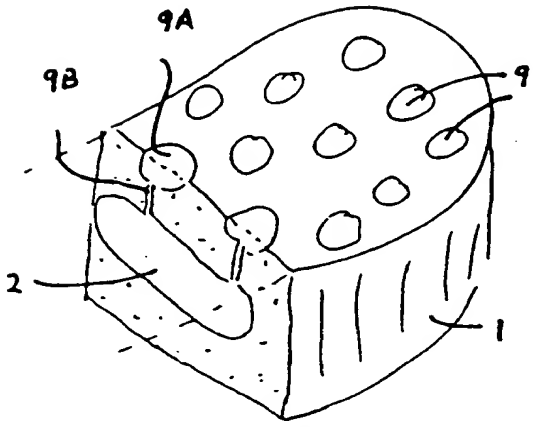


Fig. 2

Fig. 3

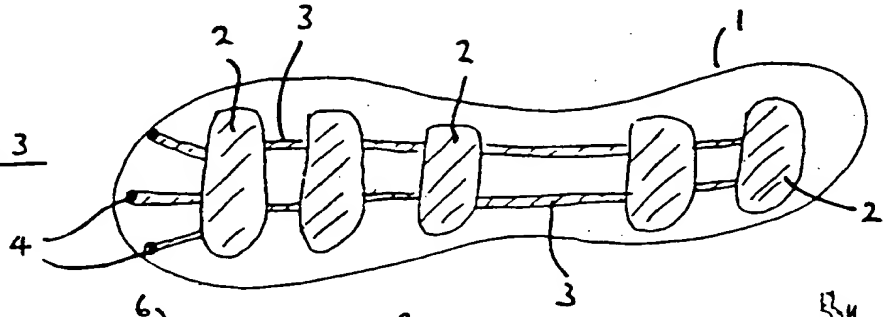


Fig. 4

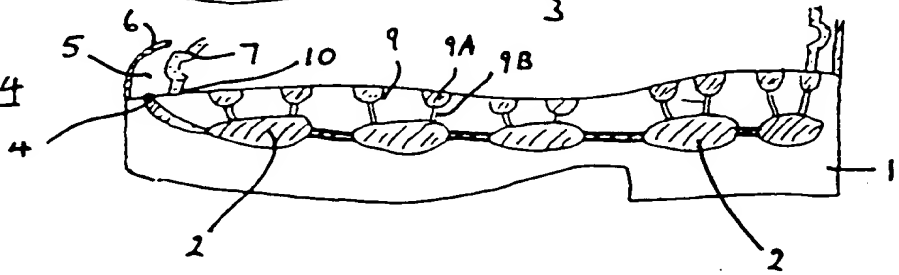
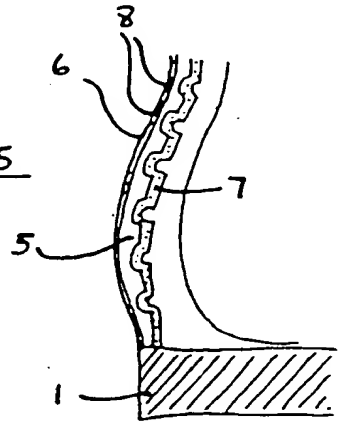


Fig. 5



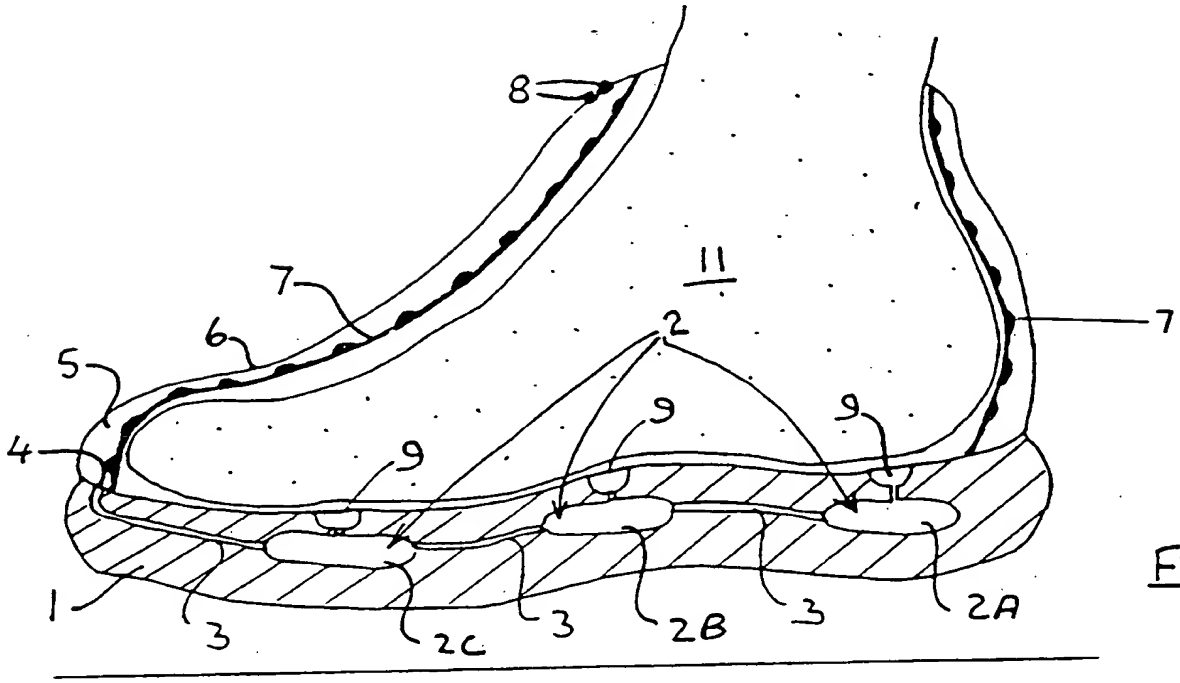


Fig.6

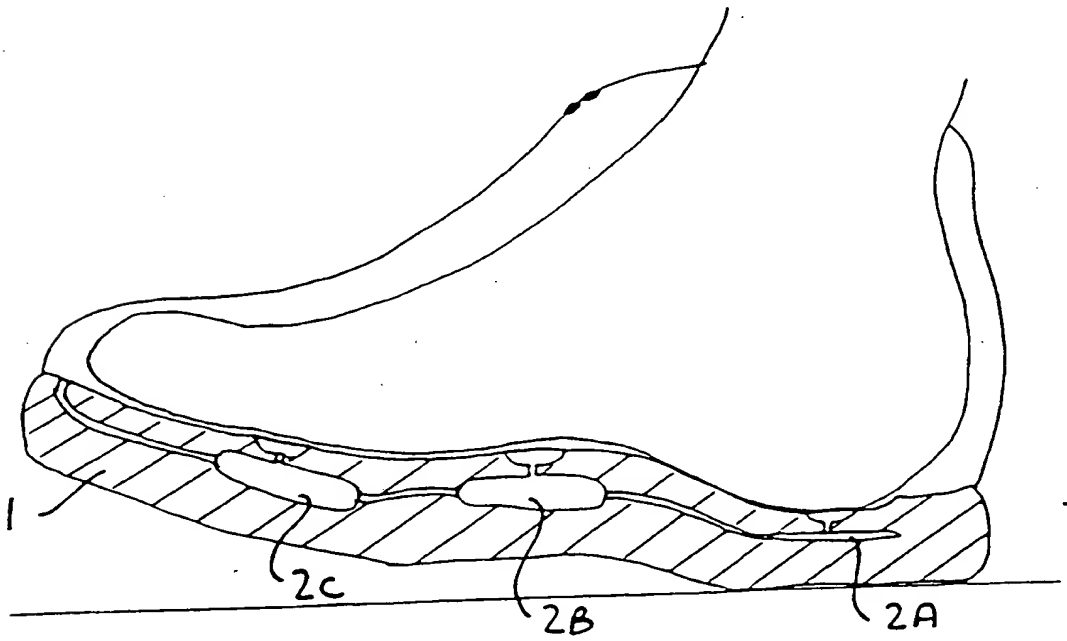


Fig.7A

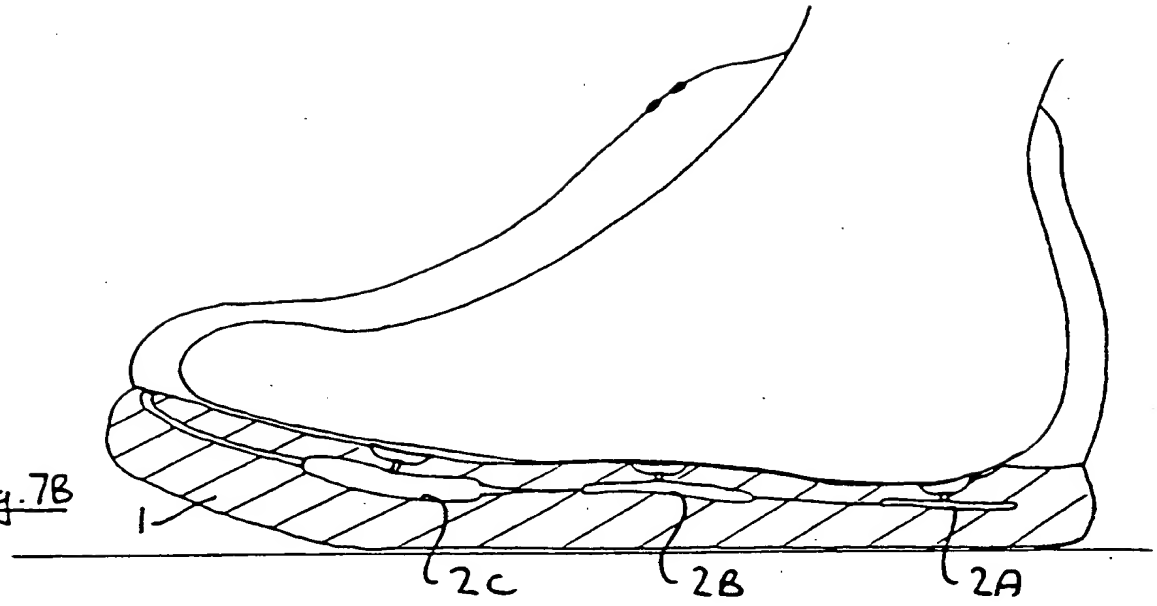


Fig. 7B

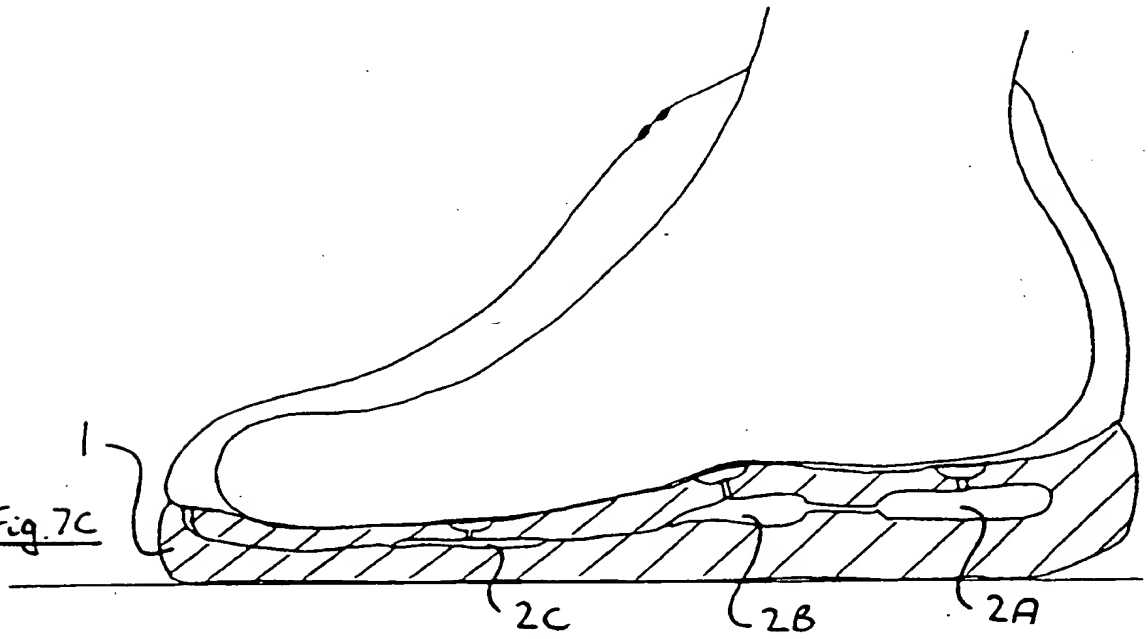


Fig. 7C

INTERNATIONAL SEARCH REPORT

Inte onal Application No
PCT/GB 96/00581

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 A43B7/06

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 A43B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	GB,A,2 238 706 (K. SHOEMAKERS) 12 June 1991 see the whole document	1
A	GB,A,2 165 439 (K. CALDWELL) 16 April 1986 see the whole document	1
A	GB,A,2 240 254 (I. COOK) 31 July 1991 see the whole document	1
A	GB,A,2 245 145 (HUI-CHENG CHU) 2 January 1992 see the whole document	1
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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
21 June 1996	08.07.96

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+ 31-70) 340-2040, Tx. 31 651 epo nl, Fax (+ 31-70) 340-3016	Declerck, J

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INTERNATIONAL SEARCH REPORT

Inte. ...nal Application No
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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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